Update March 2017:

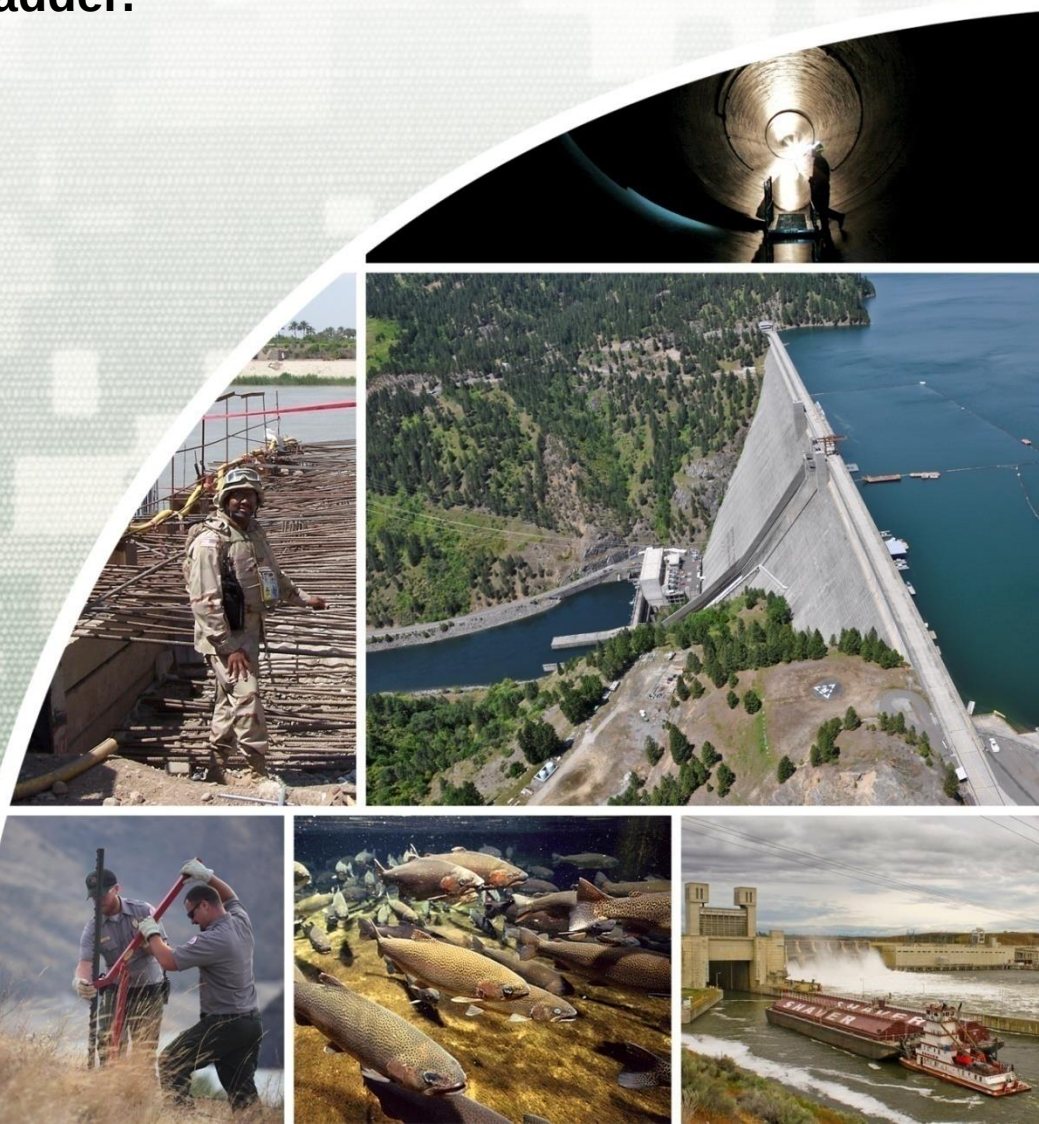
Juvenile Fish Bypass Construction, Adult PIT Arrays, and Monitoring of Post-construction Temperature Reduction and Sound/Vibration on Adult Salmon Passage through the Lower Granite ladder.

Chris Pinney Fish Biologist

Tim Wik Project Manager

Ryan Laughery Hydraulic Engineer

David Trachtenbarg Fish Biologist



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US Army Corps of Engineers

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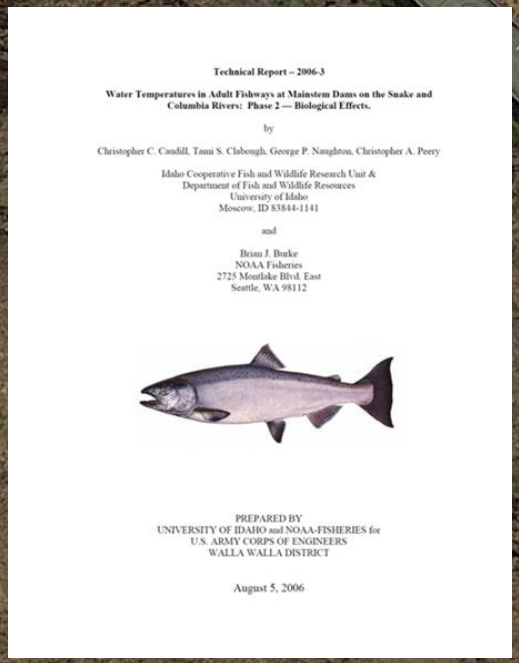
US Army Corps of Engineers ®
Walla Walla District

Water Temperature Monitoring

- ~9 locations adjusted from 2013/2014 in 2015/2016
- http://www.nwd-wc.usace.army.mil/ftppub/water_quality/tempstrings/



Technical Report – 2006-3

Water Temperatures in Adult Fishways at Mainstem Dams on the Snake and Columbia Rivers: Phase 2 — Biological Effects.

by

Christopher C. Caudill, Tami S. Clabough, George P. Naughton, Christopher A. Peery

Idaho Cooperative Fish and Wildlife Research Unit &
Department of Fish and Wildlife Resources
University of Idaho
Moscow, ID 83844-1141

and

Brian J. Burke
NOAA Fisheries
2725 Montlake Blvd. East
Seattle, WA 98112

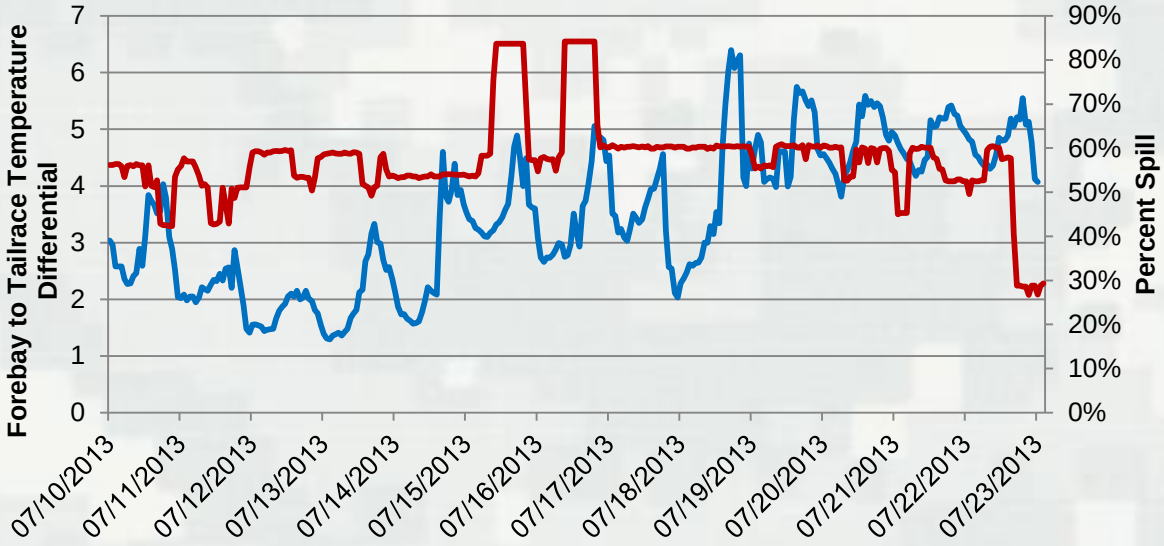
PREPARED BY
UNIVERSITY OF IDAHO and NOAA-FISHERIES for
U.S. ARMY CORPS OF ENGINEERS
WALLA WALLA DISTRICT

August 5, 2006

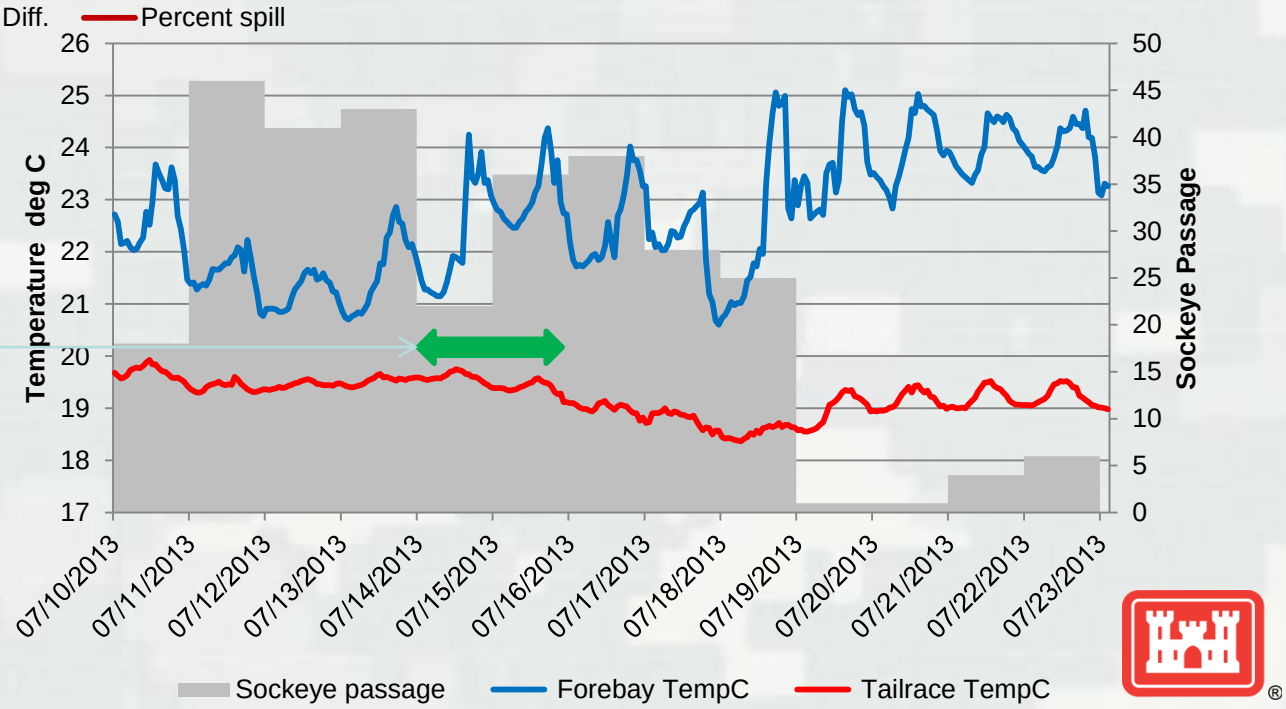
Master Unit

5 sensors @
Surface
5 feet
10 feet
30 feet
80 feet

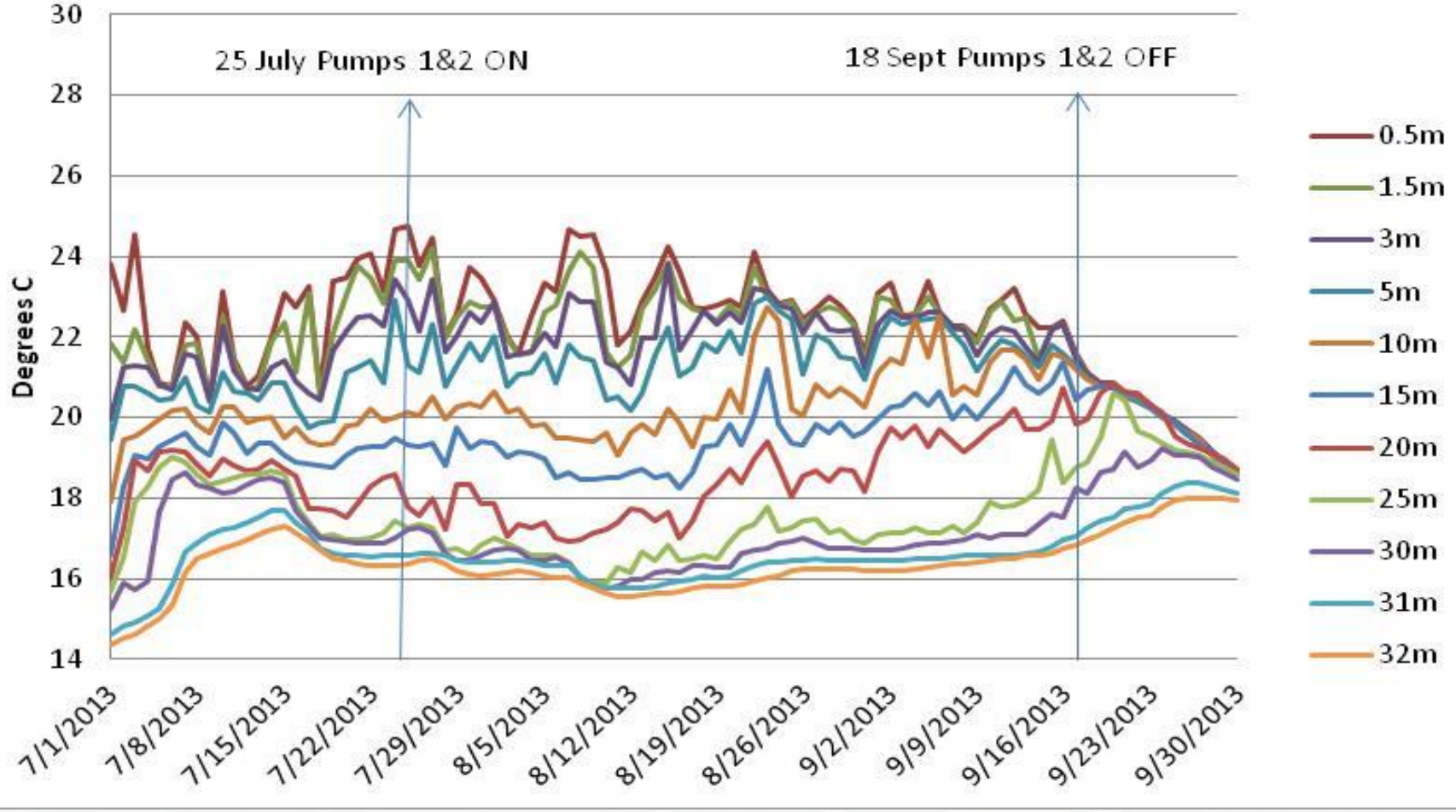
2013 Lower Granite Dam



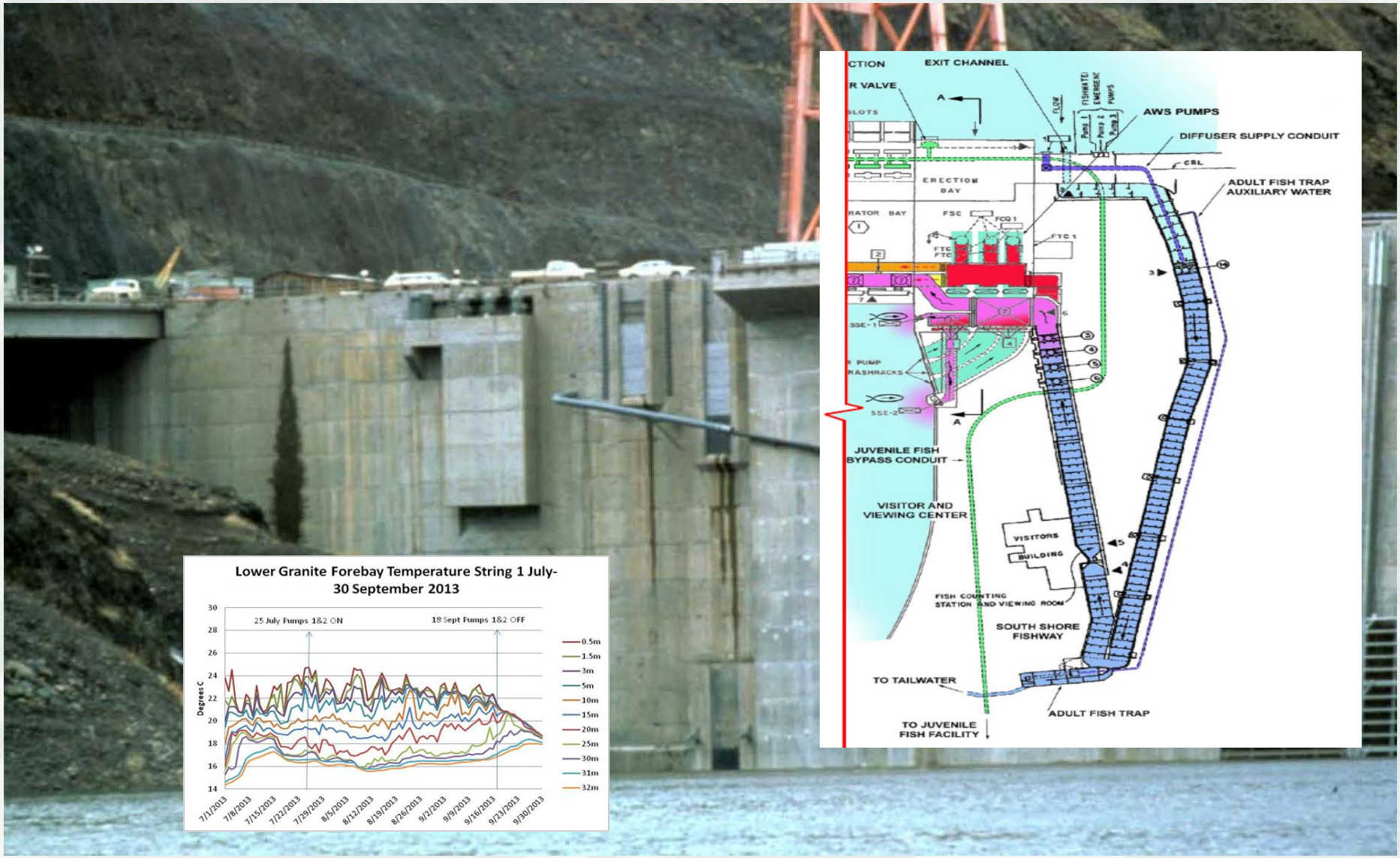
7/14-15/2013 hydraulic survey for new outfall placement:
7/14 TU2, 50% spill split
7/15 SS5kcfs TU5, 27 kcfs spill



Lower Granite Forebay Temperature String 1 July-30 September 2013



http://www.nwd-wc.usace.army.mil/ftppub/water_quality/tempstrings/LWG_S1_2013_07.html



Lower Granite Dam forebay face circa 1974

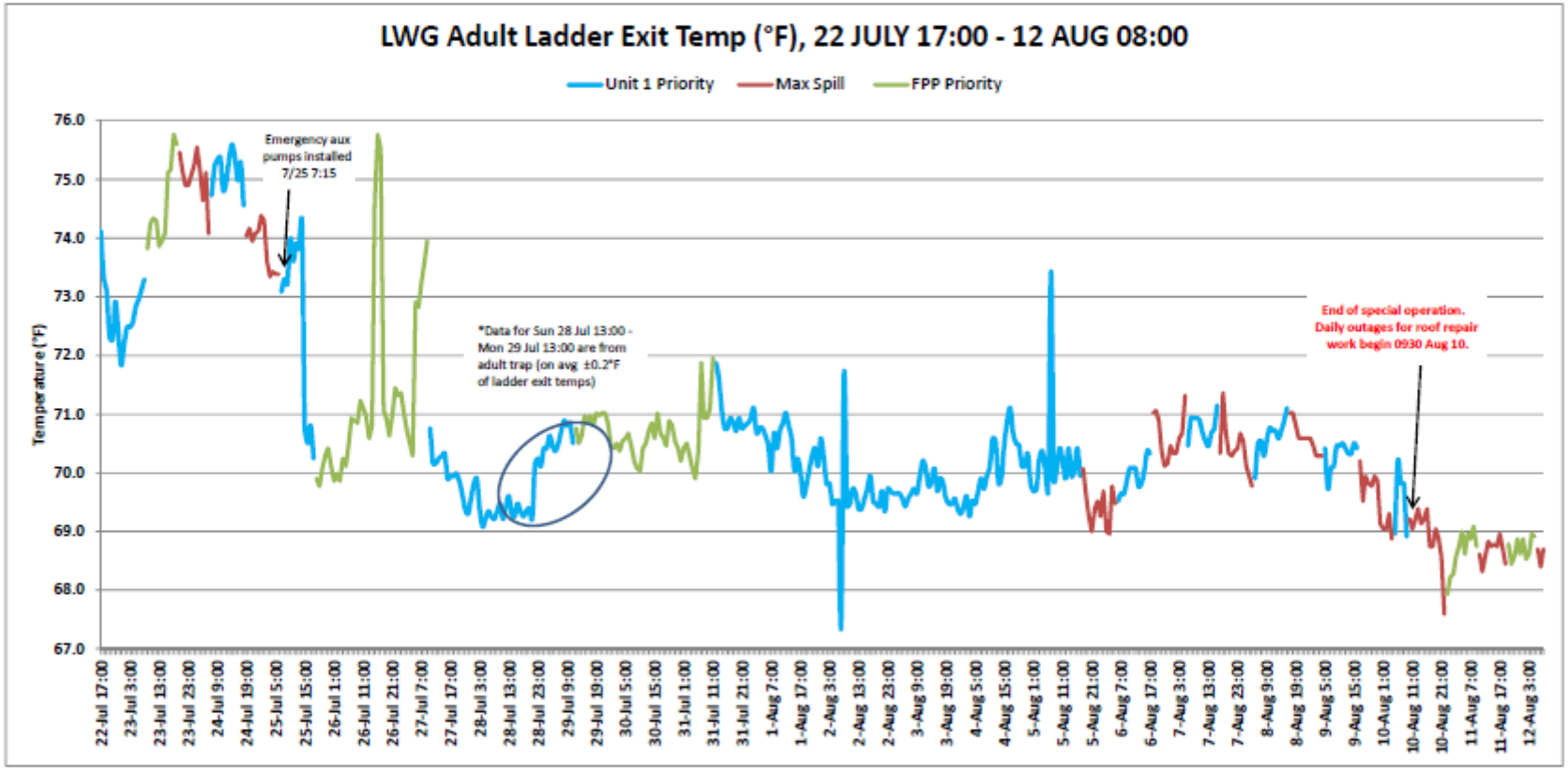
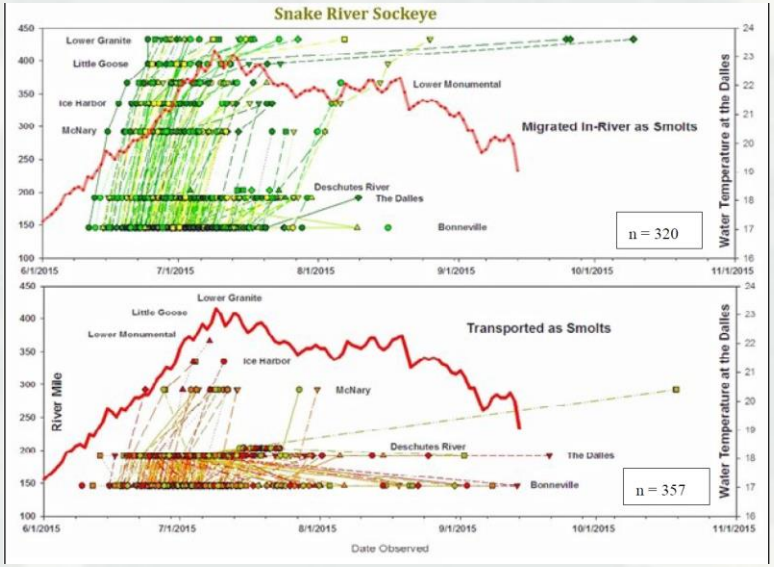

LWG Adult Ladder Exit Temp (°F), 22 JULY 17:00 - 12 AUG 08:00
Unit 1 Priority
Max Spill
FPP Priority
Temperature (°F)
76.0
75.0
74.0
73.0
72.0
71.0
70.0
69.0
68.0
67.0
Emergency aux pumps installed 7/25 7:15
*Data for Sun 28 Jul 13:00 - Mon 29 Jul 13:00 are from adult trap (on avg ±0.2°F of ladder exit temps)
End of special operation. Daily outages for roof repair work begin 0930 Aug 10.
22-Jul 17:00
23-Jul 3:00
23-Jul 13:00
23-Jul 23:00
24-Jul 9:00
24-Jul 19:00
25-Jul 5:00
25-Jul 15:00
26-Jul 1:00
26-Jul 11:00
26-Jul 21:00
27-Jul 7:00
27-Jul 17:00
28-Jul 3:00
28-Jul 13:00
28-Jul 23:00
29-Jul 9:00
29-Jul 19:00
30-Jul 5:00
30-Jul 15:00
31-Jul 1:00
31-Jul 11:00
31-Jul 21:00
1-Aug 7:00
1-Aug 17:00
2-Aug 3:00
2-Aug 13:00
2-Aug 23:00
3-Aug 9:00
3-Aug 19:00
4-Aug 5:00
4-Aug 15:00
5-Aug 1:00
5-Aug 11:00
5-Aug 21:00
6-Aug 7:00
6-Aug 17:00
7-Aug 3:00
7-Aug 13:00
7-Aug 23:00
8-Aug 9:00
8-Aug 19:00
9-Aug 5:00
9-Aug 15:00
10-Aug 1:00
10-Aug 11:00
10-Aug 21:00
11-Aug 7:00
11-Aug 17:00
12-Aug 3:00

Table 4. Estimated annual survival rates of adult Snake River sockeye salmon by adult migration year and juvenile migration history from Bonneville Dam to the Sawtooth Valley (yellow shaded cells) indicate statistically significant differences, P<0.05. Source: PTAGIS data

Adult Migration Year	Juvenile Migration History	# at BON	Survival Estimates (%)			
			BON to MCN	MCN to LGR	BON to LGR*	LGR to Sawtooth Valley
2010	Inriver	32	84	96	**81**	77
	Transported	8	88	74	**63**	80
2011	Inriver	307	64	97	**62**	75
	Transported	209	69	95	**66**	77
2012	Inriver	111	57	94	**53**	64
	Transported	11	55	67	**36**	50
2013	Inriver	136	76	76	**57**	33
	Transported	69	49	38	**19**	31
2014	Inriver	216	71	93	**66**	56
	Transported	129	43	95	**41**	55
2015	Inriver	320	26	33	**8**	29^
	Transported	357	5	0	**0**	0

* The survival estimate for the BON to LGR reach is the product of survival from (BON to MCN) x (MCN to LGR). For example, (0.84) x (0.96) = 0.81 or 81%.

^ There were 27 detections of PIT tagged adults at Lower Granite Dam in 2015 (transported and inriver juvenile migrants combined). Three of the 27 were transported to the hatchery for spawning and 24 migrated instream. Of these 24, seven (i.e., 29%) were detected in the Sawtooth Valley



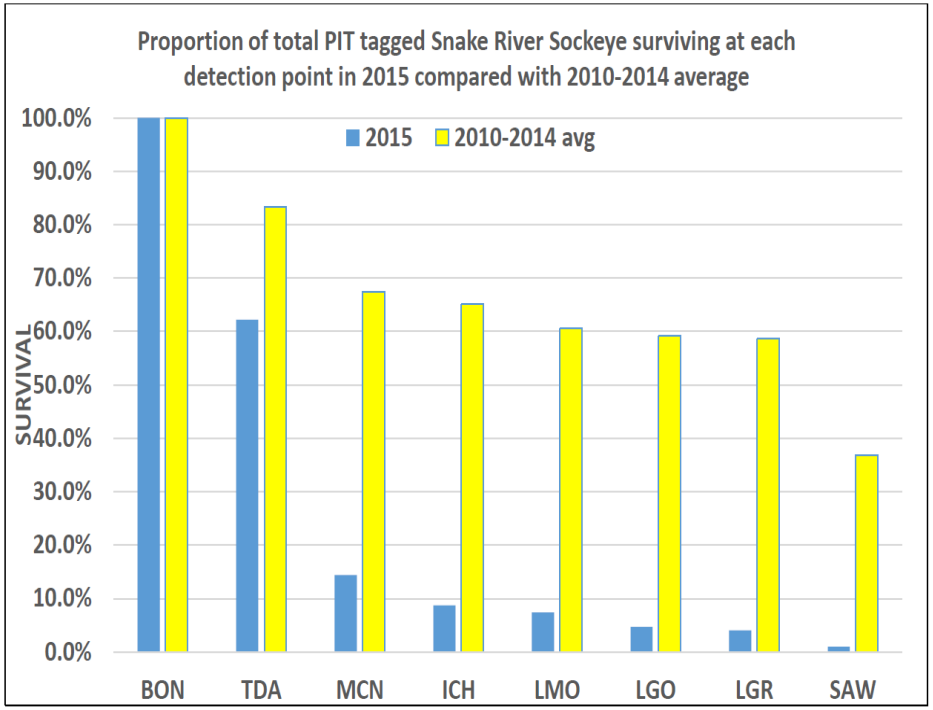
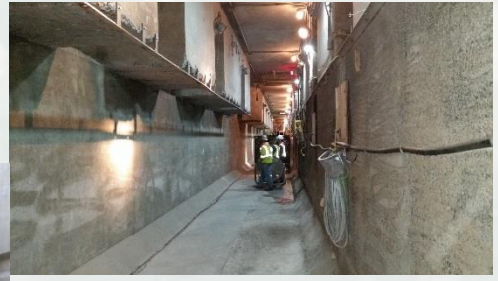


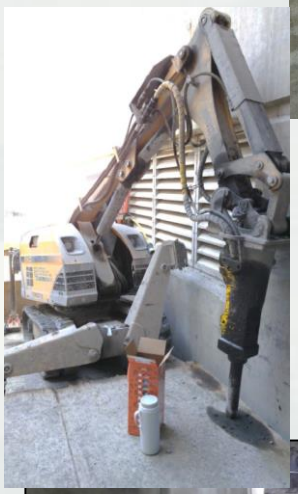
Figure 12. Proportion of total PIT-tagged Snake River sockeye salmon detected at Bonneville Dam that survived to each subsequent detection point (The Dalles, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams and the Sawtooth Hatchery weir) in 2015 compared to average for 2010-2014. Source: PTAGIS data

Lower Granite Juvenile Fish Bypass System (JFF Upgrade)

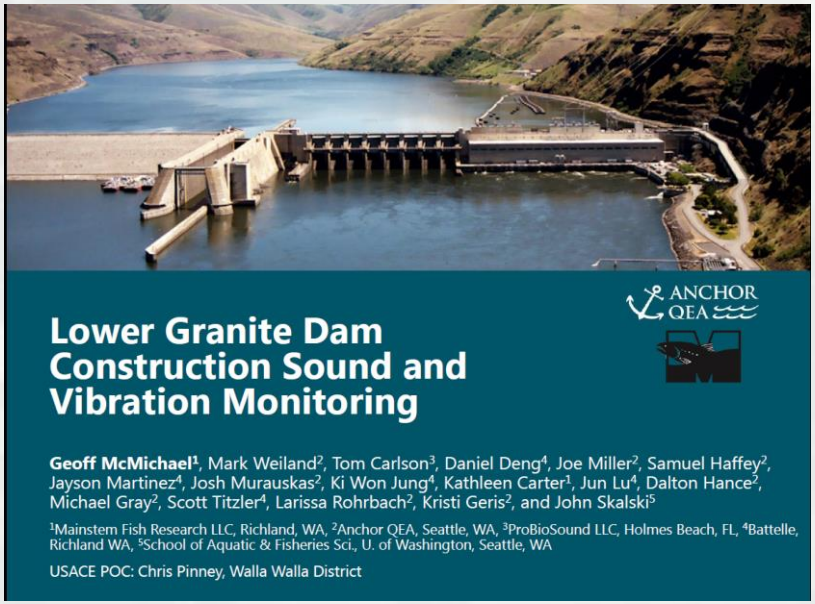
- Phase 1A
  - Turbine gatewell orifices to JFF juvenile fish separator
    - Construction began late 2014
    - Project Completion - March 2018
- Phase 1b
  - Primary outfall pipe redesign and relocation
    - Construction ~November 2016 to March 2018




Phase 1A




49



January 2017
Lower Granite Adult Passage Evaluation

Sound and Vibration Characterization Report

Prepared for
U.S. Army Corps of Engineers
201 North Third Avenue
Walla Walla, Washington 99362-1876

Prepared by
Anchor QEA, LLC
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65 Park Street
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622 Dundee Ln
Holmes Beach, Florida 34217

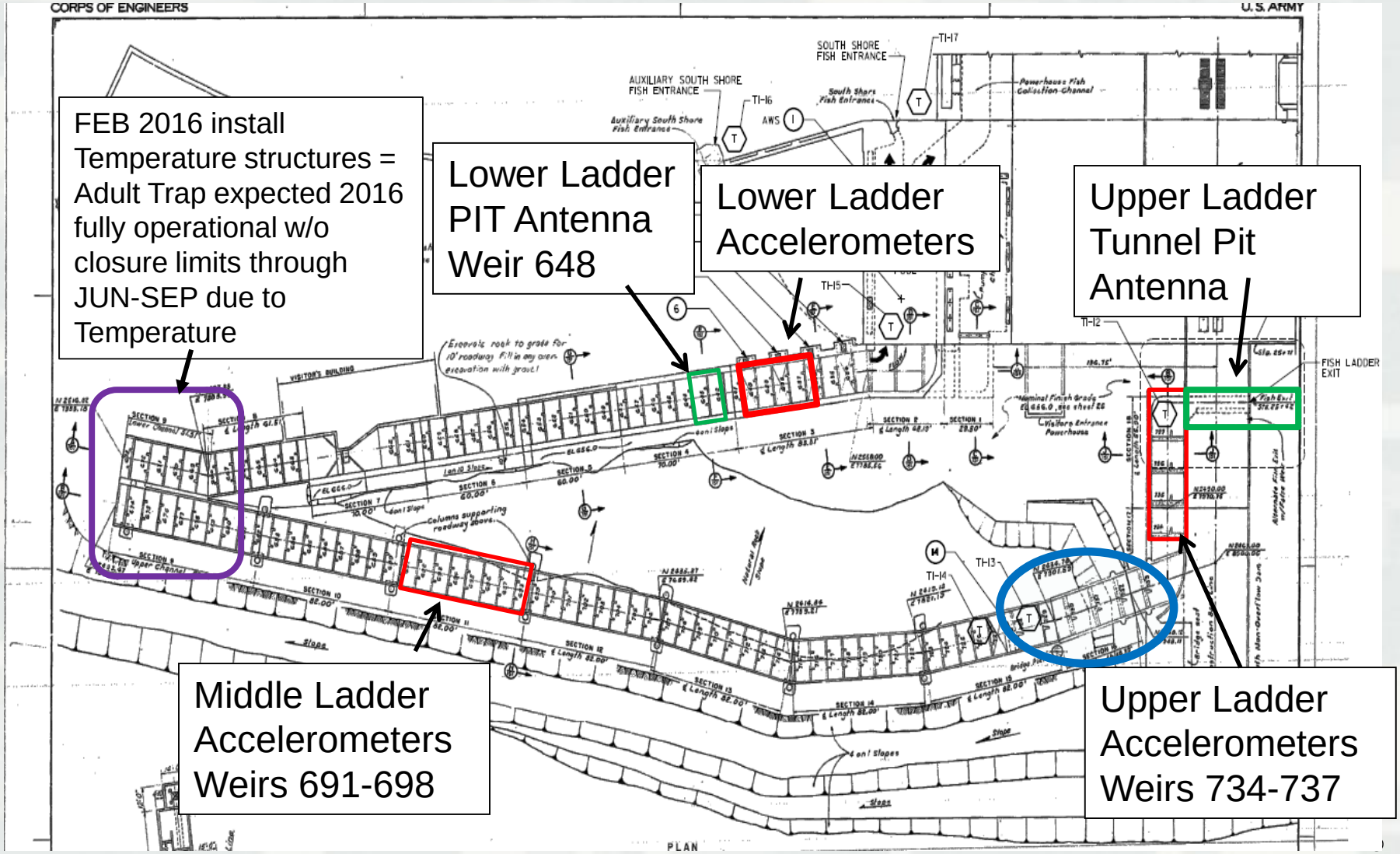
Pacific Northwest National Laboratory
P.O. Box 999
Richland, Washington 99352

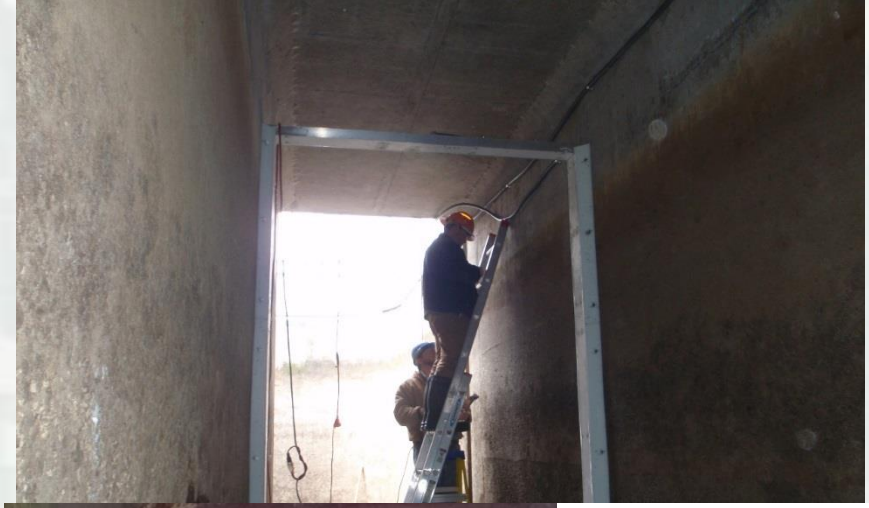
Draft S&V Characterization Report out January 2017.

Final S&V Characterization Report due 30 March 2017.

Draft Adult Salmon Passage Behavior Response Report due 30 March 2017 for ~45 day Review.

Lower Granite Monitoring Locations





Lower Granite Dam PIT Antennae Coil Designations and Locations

	Type	Antenna
Weir 730	Slot	1
Weir 731	Slot	3
Weir 732	Slot	5
Weir 733	Slot	7
Weir 730	Orifice	2
Weir 731	Orifice	4
Weir 732	Orifice	6
Weir 733	Orifice	8
Trap		12
Trap		14
Trap		16
Trap		18
Trap		22
Trap		24
Trap		26
Trap		28
Exit Pool top		A1
Exit Pool bottom		A2
Entrance orifice	Orifice	B3
Entrance orifice	Orifice	B4
Entrance weir	weir	B1
Entrance weir	weir	B2

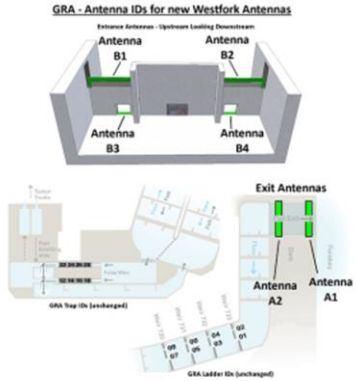


Table 1
Percent of Peak Acceleration Values that Exceeded the Salmonid Behavioral Response Threshold by Time, Activity, and Location

		Fishway Monitoring Location		
Activity	**Period**	**Upper**	**Middle**	**Lower**
Non-Construction	Day	26.52	99.96	0.01
Non-Construction	Night	31.53	99.96	0.02
Construction	Day	24.38	99.97	0.06
Construction	Night	34.53	99.96	0.26

Note:

Salmonid behavioral response threshold is 80 dB//1 µm/s².

Figure 10
Peak Acceleration Magnitudes Observed in the Upper Section of the Fishway, September 29 Through October 4, 2015

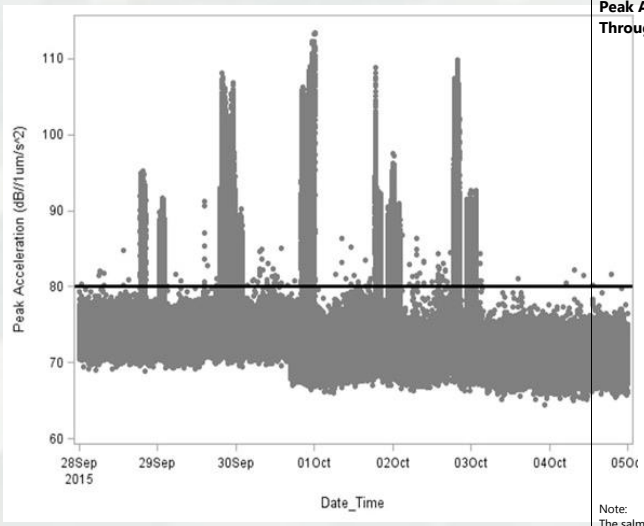
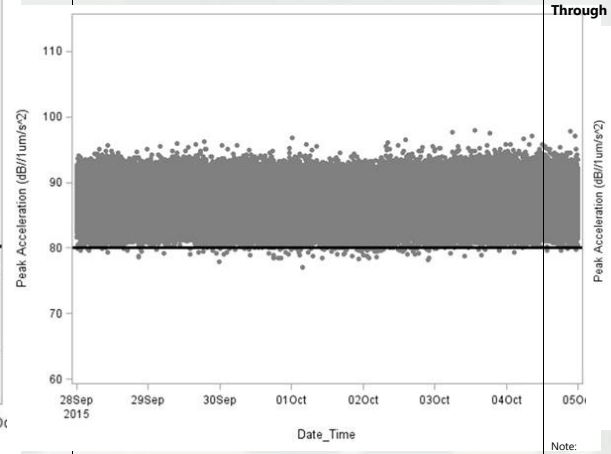
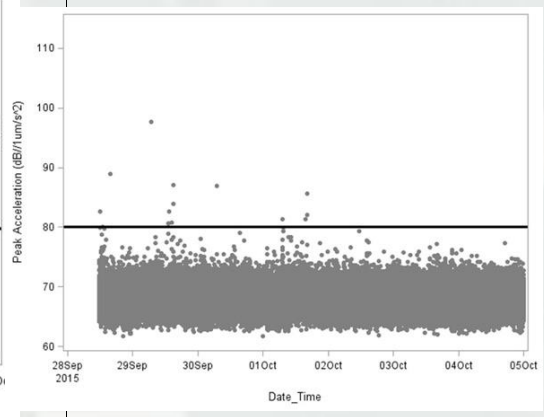


Figure 9
Peak Acceleration Magnitudes Observed in the Middle Section of the Fishway, September 29 Through October 4, 2015



Note:
The salmonid behavioral response threshold (horizontal black line) is 80 dB//1 µm/s².

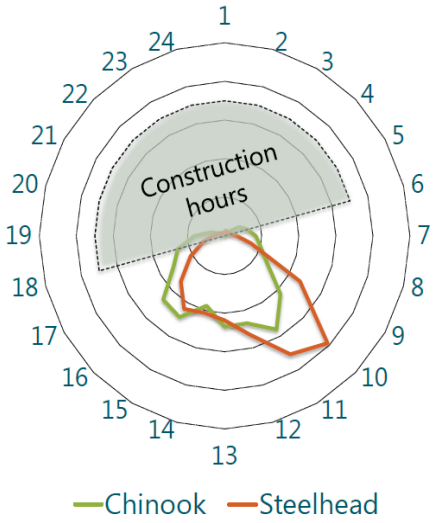
Figure 8
Peak Acceleration Magnitudes Observed in the Lower Section of the Fishway, September 29 Through October 4, 2015



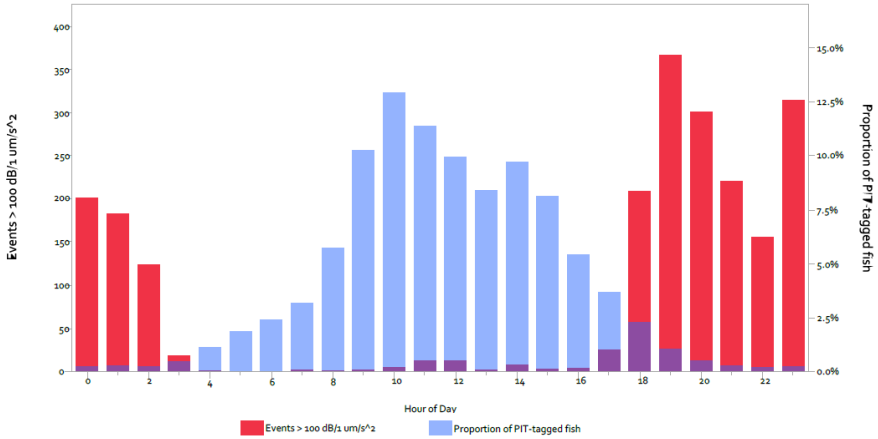
Note:
The salmonid behavioral response threshold (horizontal black line) is 80 dB//1 µm/s².

2015 Construction Timing and Passage

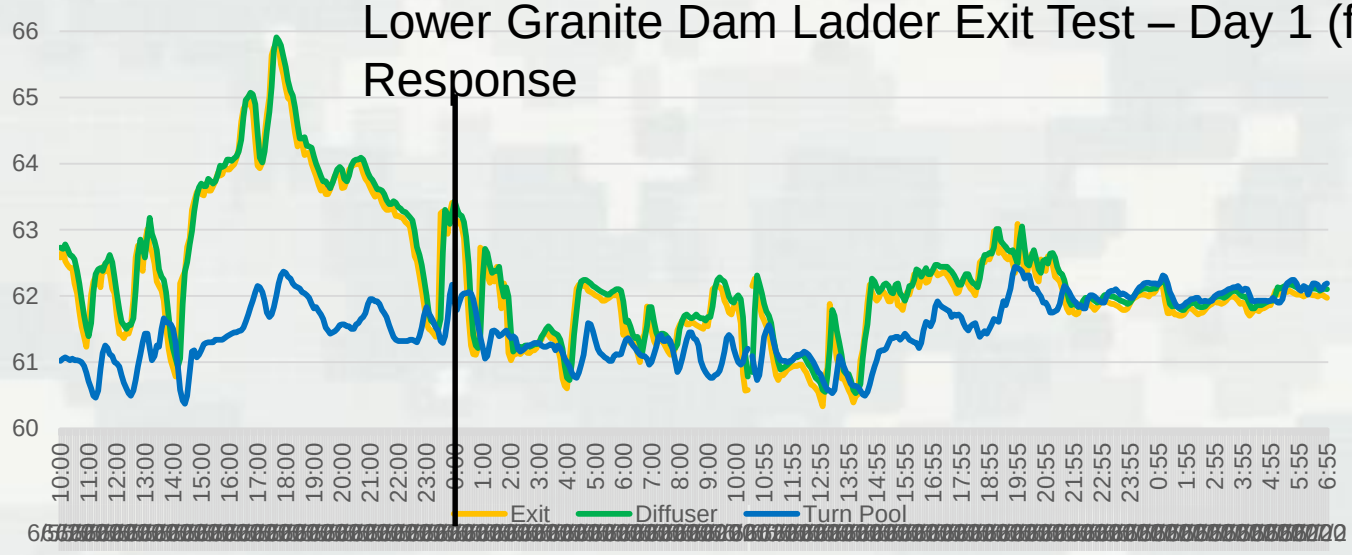
- Construction at night
- Limited study fish during night hours
  - 10.8% of Chinook salmon
  - 6.8% of steelhead



High magnitude events *vs* fish passage timing



Lower Granite Dam Ladder Exit Test – Day 1 (first 24 hrs) Response



Average	Shower OFF	Shower ON
1030 to 1030	6/5/2016	6/6/2016
Trap	60.43076	61.41671
TurnPool	61.35462	61.68118
Diffuser	62.62913	61.95598
Exit	62.52031	61.86045
FBExitS	62.9941	62.40244
FBExitN	63.1809	61.80992
Differential	1.165694	0.179268

Lower Granite Dam Ladder Travel Time
(PIT detection time in hours, delta Temperature 1-4° F @ site, Diff T ~<1-3.5° F)

Summary TT (hours)	Shower	N	Min	Max	Average	Median
May 30 1038 to June 1 0638	Off	11	0.08	1.53	0.37	0.13
June 6 1038 to June 8 0638	On	21	0.07	0.42	0.16	0.11

Lower Granite Dam Ladder Exit Pool Residence Time
(PIT detection time in minutes, delta Temperature 1-4° F @ site, Diff T ~<1-3.5° F)

Summary TT (minutes)	Shower	N	Min	Max	Average	Median
May 30 1038 to June 1 0638	Off	118	0.1	30.0	4.9	3.4
June 6 1038 to June 8 0638	On	23	0.2	13.1	2.8	0.7

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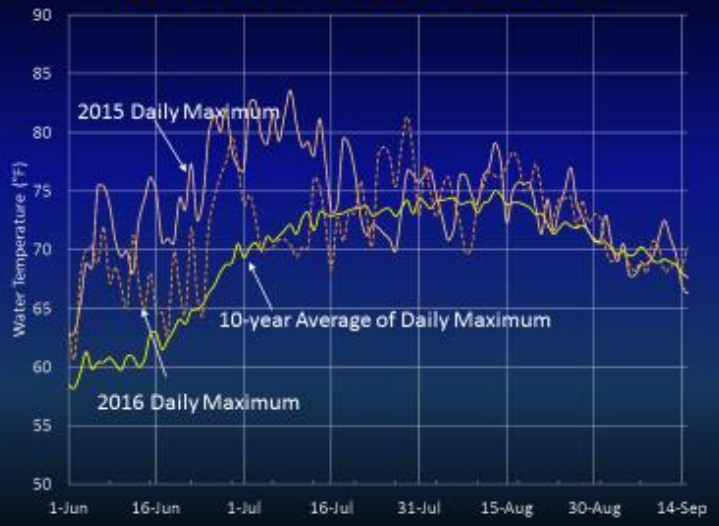
Post-construction Evaluation of Adult Fishway Temperature Differential Reduction at Lower Granite Dam in 2016

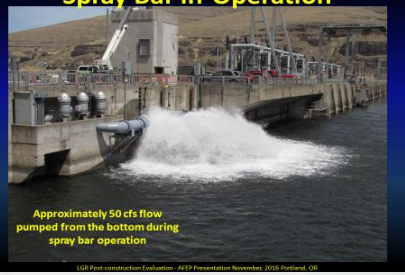
Peter Johnson (LGL)
Pradeep Mugunthan, Joe Miller, Samuel Haffey, Mark Weiland, Josh Murauskas, Dakota Passero, Jenny DiGiulio, Zheng Wang (Anchor QEA)
John Skalski, Rich Townsend (University of Washington)

LGL Alaska Research Associates, Inc. | ANCHOR QEA

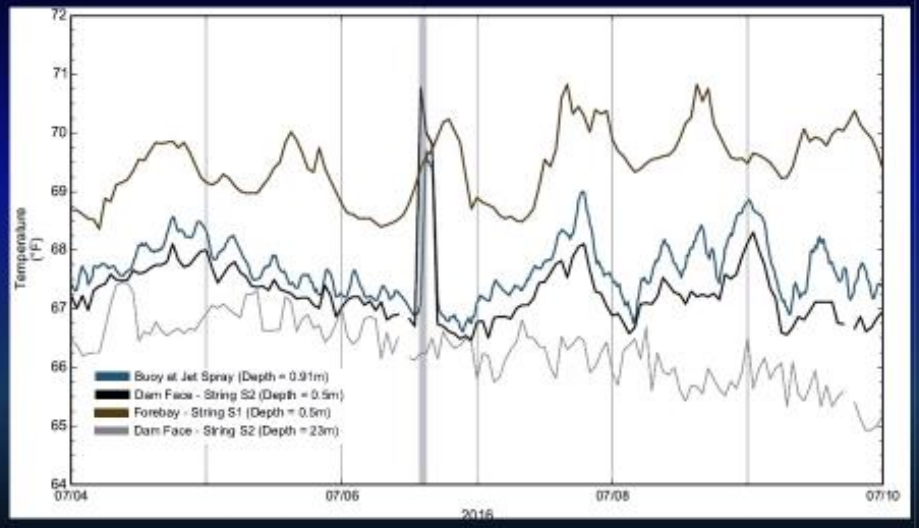
Historical Temperatures in the Forebay (at 0.5 m below surface)



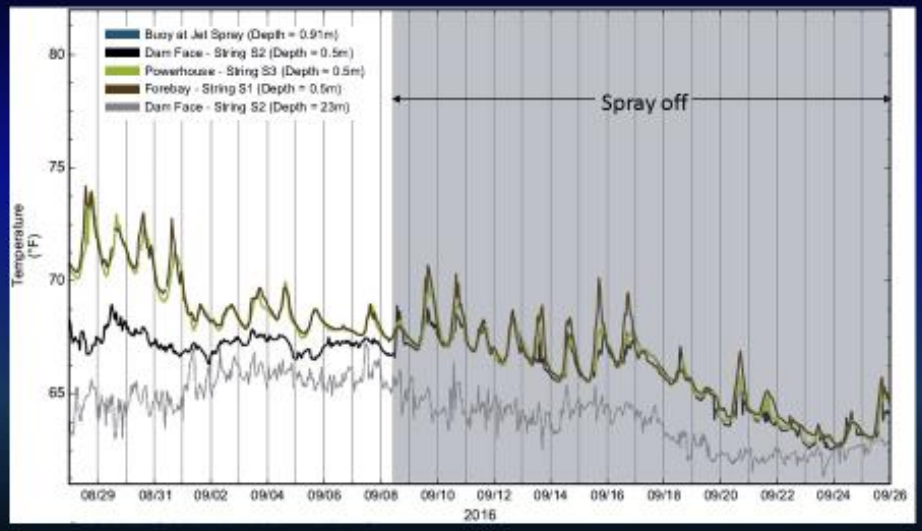
Spray Bar in Operation



Temperature Results: July



Temperature Results: September

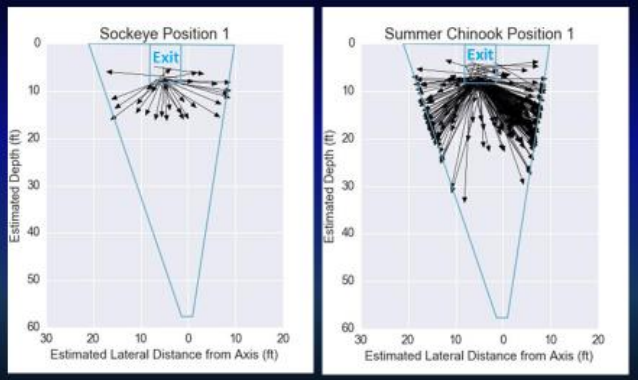


Conclusions: Fish Behavior

Sockeye-sized Fish

- No preferred lateral direction
- Do not immediately go very deep
- Appear to promptly move upstream
- More deeply distributed further upstream

Fish Behavior Results

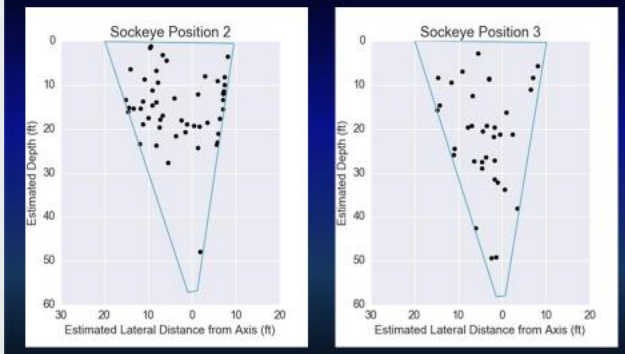


Conclusions: Fish Behavior

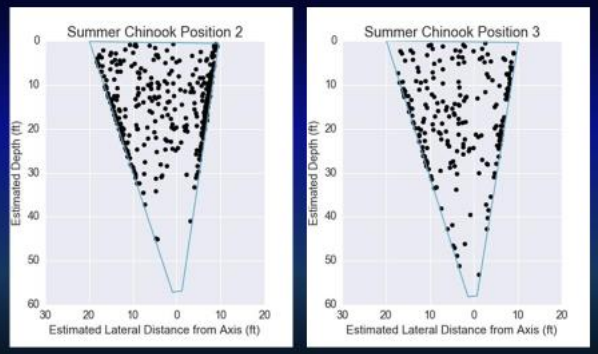
Chinook-sized Fish

- Prefer moving east
- Some immediately go deep
- Appear to delay upstream movement
- Depth distribution fairly uniform further upstream

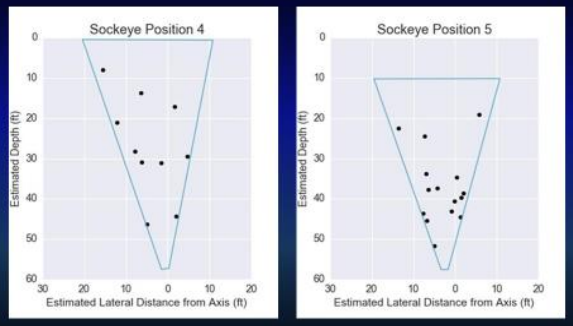
Sockeye-sized Fish



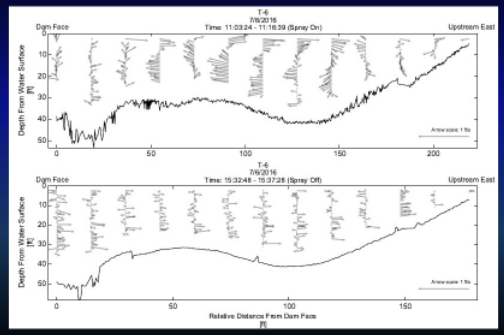
Chinook-sized Fish



Sockeye-sized Fish



Velocity Profiles at Transect T6



Chinook-sized Fish

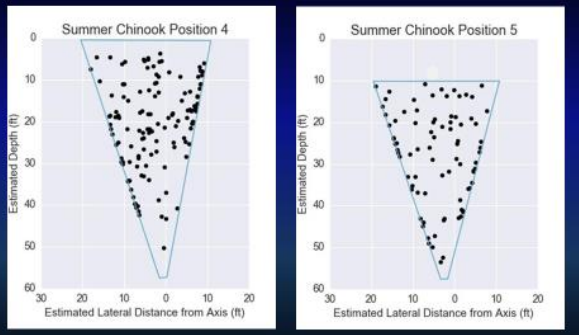


Table 1. Status of PIT-tagged Chinook, sockeye, and steelhead in the Lower Granite Dam fishway, 2015.

		Trapped and tagged passage		Routed through trap		Unrestricted	
Species Name	**Run Name**	**N**	**Row %**	**N**	**Row %**	**N**	**Row %**
Chinook	Fall	0	0.0%	1,667	98.0%	34	2.0%
	Spring	2,604	58.9%	1,682	38.0%	137	3.1%
	Summer	393	40.0%	374	38.1%	215	21.9%
	Unknown	0	0.0%	1,151	92.0%	100	8.0%
	All	2,997	35.9%	4,874	58.3%	486	5.8%
Sockeye	Summer	0	0.0%	6	20.0%	24	80.0%
	All	0	0.0%	6	20.0%	24	80.0%
Steelhead	N/A	0	0.0%	6	75.0%	2	25.0%
	Resident	0	0.0%	2	100.0%	0	0.0%
	Summer	4,536	59.6%	2,932	38.5%	146	1.9%
	Unknown	0	0.00%	106	84.1%	20	15.9%
	All	4,536	58.5%	3,046	39.3%	168	2.2%
All	**All**	**7,533**	**46.7%**	**7,926**	**49.1%**	**678**	**4.2%**

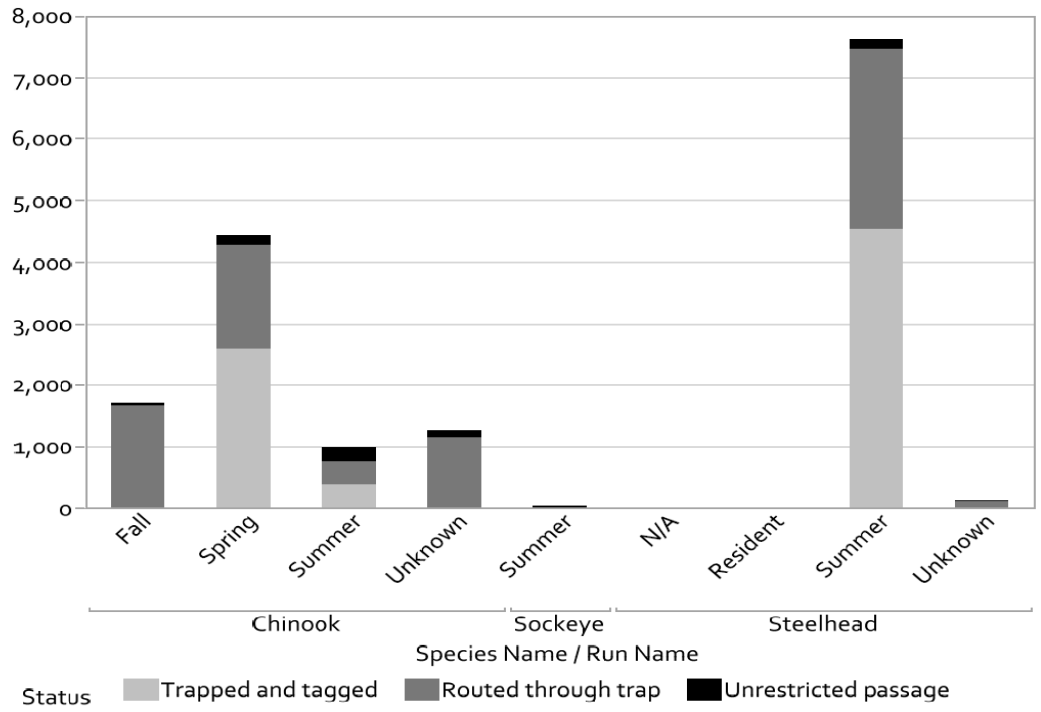


Figure 2. Status of PIT-tagged Chinook, sockeye, and steelhead in the Lower Granite Dam fishway, 2015.

Figure 1. Box plots of passage duration (from entrance to exit) of PIT-tagged adult Chinook salmon at Lower Granite Dam in 2016 by day of week prior to August 18. Whiskers represent Q1 – 1.5 × interquartile range or Q3 + 1.5 × interquartile range; the box encompasses Quartile 1, Quartile 2 (median, shown by transparent line), and Quartile 3. Positive outliers and maximum values are not shown to focus on a scale representing a majority of passage events. **Delays are significantly different between weekdays (with trapping) and weekends (Median Test, $p < 0.001$).**

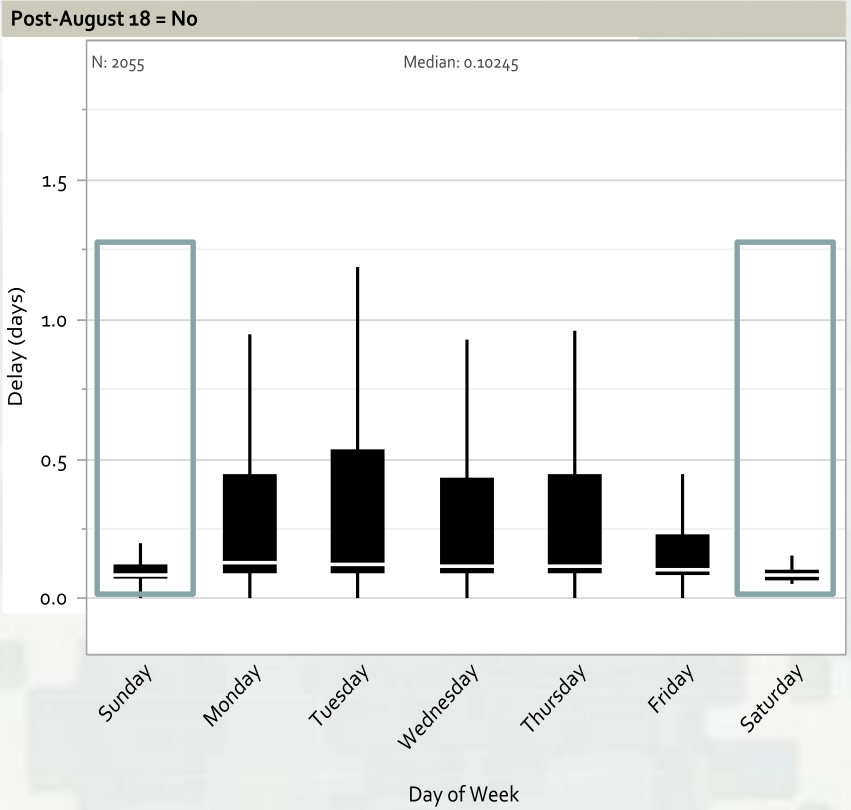
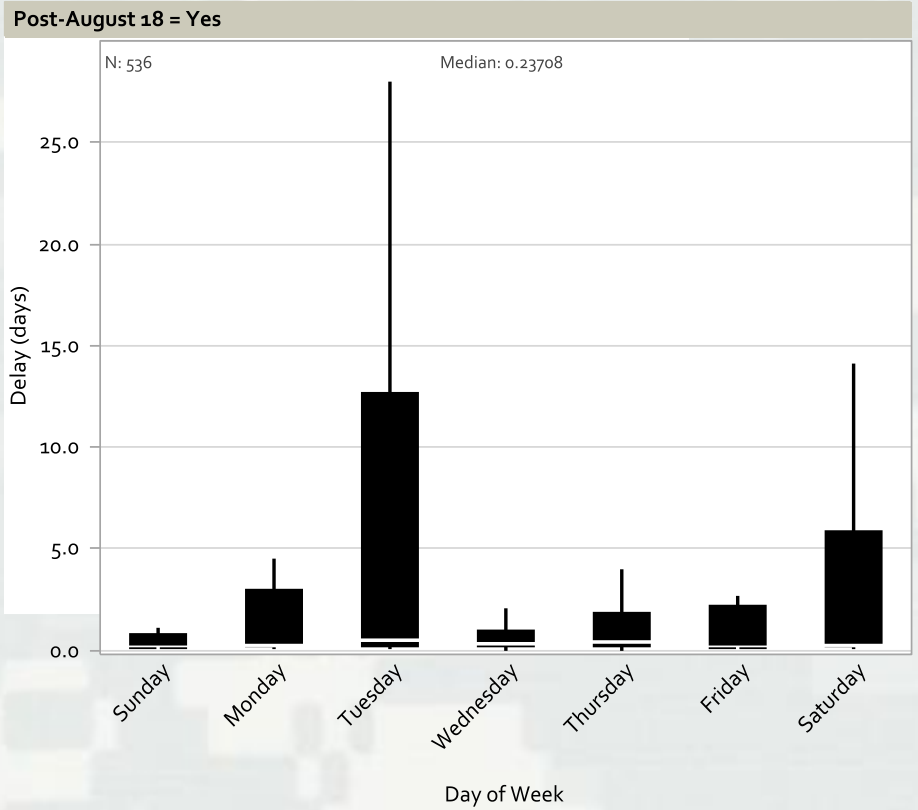
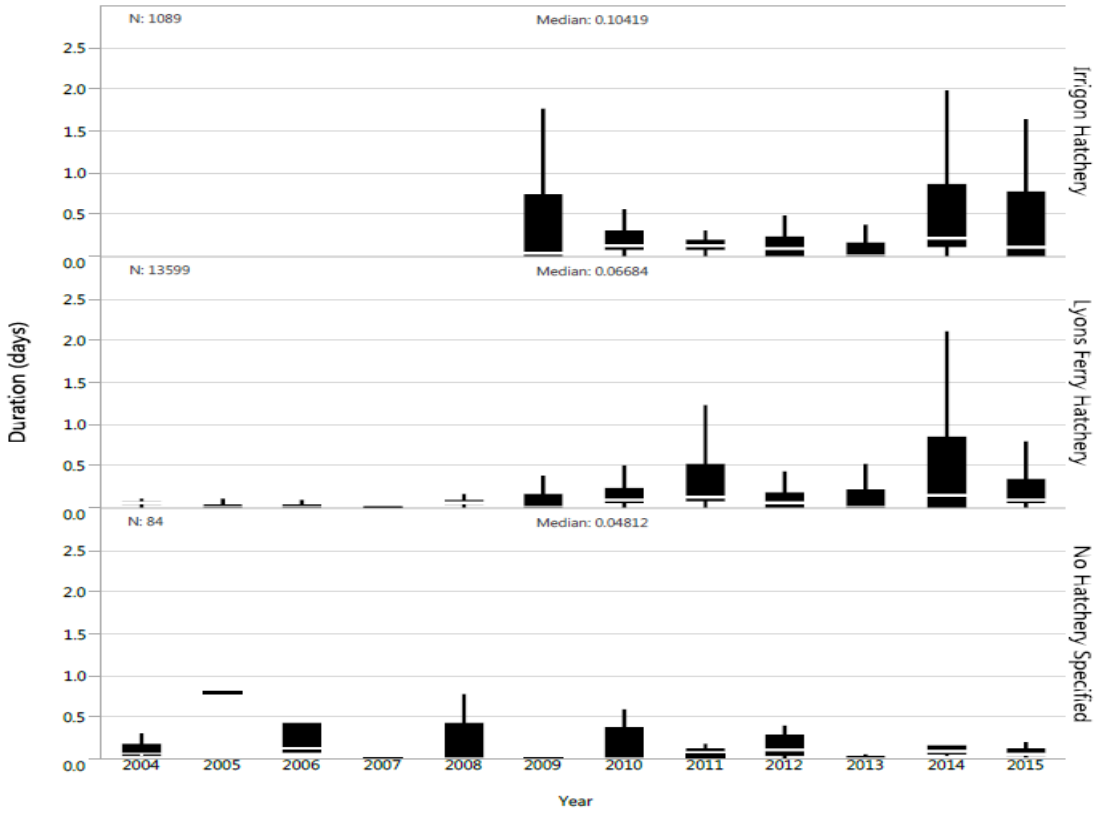


Figure 2. Box plots of passage duration (from entrance to exit) of PIT-tagged adult Chinook salmon at Lower Granite Dam in 2016 by day of week after August 18. Whiskers represent Q1 – 1.5 × interquartile range or Q3 + 1.5 × interquartile range; the box encompasses Quartile 1, Quartile 2 (median, shown by transparent line), and Quartile 3. Positive outliers and maximum values are not shown to focus on a scale representing a majority of passage events. **Delays are not significantly longer on weekdays than weekends (Median Test, $p = 0.098$); although delays are significantly than prior to August 18 ($p < 0.001$).**





Hatchery fish (top panels) more likely to spend time in fishway compared to wild fish (bottom)

Duration Between First and Last Detections in Fishway from 2004 to 2015

Table 6. Adult Chinook counts in the ladders at Lower Granite Dam during July 25–August 10, 2013, when emergency pumps were in operation and Turbine Unit 1 alternated with Unit 2. The operation was designed to enhance tailrace conditions while spilling water up to the Total Dissolved Gas cap (120% of saturation) as measured in the tailrace at each project. Source: USACE data

Number of Adults	Unit 2	Unit 1
Ascending Ladder	260	2,021
Descending Ladder	232	1,337
Net Ascending	28	684
Hours Operated	88	239
Net Ascending / Hour	0.3	2.9

Figure 15. Tailrace conditions at Lower Granite Dam in July 2013 showing the reverse eddies with Turbine Unit 2 operating (left) and improved downstream flow with Unit 1 operating (right). Circles show ladder entrances. Arrow on the left shows the direction of the back eddies, which can confuse adults trying to orient into the current to move upstream. Arrows on the right show the direction of flow (away from the ladder entrance) without the reverse eddies. Photo courtesy of Darren Ogden (Northwest Fisheries Science Center).